

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner  
US Department of Commerce  
United States Patent and Trademark  
Office, PCT  
2011 South Clark Place Room  
CP2/5C24  
Arlington, VA 22202  
ETATS-UNIS D'AMERIQUE  
in its capacity as elected Office

<b>Date of mailing (day/month/year)</b> 07 June 2001 (07.06.01)	
<b>International application No.</b> PCT/NL99/00586	<b>Applicant's or agent's file reference</b> P50938PC00
<b>International filing date (day/month/year)</b> 21 September 1999 (21.09.99)	<b>Priority date (day/month/year)</b>
<b>Applicant</b> BAKKER, Thomas, Walburgis	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

20 April 2001 (20.04.01)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

<b>The International Bureau of WIPO</b> 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No.: (41-22) 740.14.35	<b>Authorized officer</b> Olivia TEFY Telephone No.: (41-22) 338.83.38
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5/ppts

Amended

Title: Method and device for moving a tube in a borehole in the ground

#### FIELD AND BACKGROUND OF THE INVENTION

This invention relates to a method for axially moving a tube in a borehole in the ground according to the introductory portion of claim 1. The invention further relates to a device for axially moving a tube into a borehole in the ground according to the introductory portion of claim 19.

Such methods and devices are known from practice, for instance for axially inserting a tube in a borehole or for axially retracting tube from a borehole. Such a tube may be used for the drilling process and simultaneously for the protection of the newly drilled wellbore. This technique is commonly referred to in the field as casing drilling. Such a borehole can be used for extracting oil or gas and for other purposes, such as for the extraction of salt or geothermal energy and also for civil engineering purposes such as laying pipelines under rivers.

When using the known methods and devices, usually a first tube part is inserted into a borehole in the ground provided by a drill. Subsequently further tube parts are coupled to the upper end of the tube reaching into the borehole, e.g. via a screw and/or clamp coupling. As the tube is introduced further into the ground, successive tube parts, which can each be composed of one or more pre-connected tube joints, are connected to the proximal end of the composed section of the tube end projecting from the ground until the tube has reached its final length. When the tube is removed, this method is essentially reversed.

During insertion or retraction the composed tube is driven to rotate about its axis in a fixed direction, such that continuous rotation is achieved. This is done to provide

Claims

1. A method for axially moving a tube in borehole in the ground, wherein the tube is moved simultaneously along and about its axis, characterised in that moving the tube about its axis comprises a series of alternating, angularly  
5 opposite, rotating movements, within a limited angular range of rotation.
2. A method according to claim 1, characterised in that the limited angular range of rotation is preselected to comprise comprises less than 1800°, preferably less than 1080°, in  
10 particular less than 720°.
3. A method according to claim 1 or 2, characterised in that the time needed to complete two consecutive, alternating angularly opposite rotating movements is at least 10 s, preferably at least 20 s.
- 15 4. A method according to claim 1 or 2, characterised in that the time for completing two consecutive, alternating angularly opposite rotating movements is such that an oscillation is generated that corresponds to the base or higher order natural frequency of the tube.
- 20 5. A method according to any of claims 1-4, wherein a series of alternating, angularly opposite, rotating movements within the pre-selected angular range of rotation is preceded and/or succeeded by a non-oscillating, continuous rotating movement about its axis.
- 25 6. A method according to any of claims 1-5, characterised in that said tube is composed by connecting successive tube parts rotationally rigid end-to-end.
7. A method according to claim 6, characterised in that tube parts are connected end-to-end by welding.

8. A method according to claim 6 or 7, **characterised in that** said tube parts are connected while axially inserting the tube into the borehole.
9. A method according to any of claims 1-8, **characterised**
- 5 **in that** the tube is axially moved into the borehole in the ground to form a casing for a borehole..
10. A method according to claim 9, wherein the tube is inserted while a borehole is being drilled by a drill.
11. A method according to any of the previous claims,
- 10 **characterised in that** the pre-selected angular range of rotation includes less than 360°, preferably less than 180° to remove ground in a circular segment at the tube end, such that, when the tube is axially advanced into the borehole, a tip of the tube is advanced along a curved path.
- 15 12. A method according to any of the preceding claims, **characterised in that** the torque exerted on the tube at the surface is measured while performing angularly symmetrical opposite, rotating movements within the pre-selected angular range to determine a mid-point of lower torque values.
- 20 13. A method according to any one of the preceding claims, **characterized in that** relative angular orientation of tube sections axially spaced apart is monitored.
14. A method according to claim 13, **characterized in that** said monitoring includes observing an axial line provided on
- 25 the outside of the tube.
15. A method according to claim 13, **characterized in that** said monitoring includes detecting angular orientations of axially spaced magnetic markings on the outside of the tube.
16. A method according to claim 15, **characterized in that**
- 30 said series of alternating, angularly opposite, rotating movements have an azimuth at the tube tip, said azimuth at the tube tip being controlled in response to the orientation of the tube in the area of the ground surface.
17. A method according to claim 16, **characterized in that** a

an alternating torque having an azimuth is exerted to said tube, said azimuth at the tube tip being further controlled in response to the orientation of the tube in the area of the ground surface when said azimuth of said torque occurs.

- 5 18. A method according to any one of the preceding claims characterised in that pumping of mud is continued while a connection with a next tube section is being made via a hose and packer combination which sealingly connects to the tube section in the hole.
- 10 19. A device for axially moving a tube in a borehole in the ground, comprising means for moving the tube along and about its axis, characterised in that the means for moving the tube about its axis comprises a rotational drive that is operatively coupled to control means for controlling the
- 15 drive to perform alternating, angularly opposite, rotating movements within a limited angular range of rotation.
20. A device according to claim 19, characterised in that the limited angular range of rotation is preselected to comprise less than 1800°, preferably less than 1080°, in
- 20 particular less than 720°.
21. A device according to claims 19 or 20, characterised in that the rotational drive and the control means are further configured to selectively control the drive to perform a continuous, non-alternating, rotating movement.
- 25 22. A device according to any of claims 19-21, characterised in that it comprises a welding apparatus for welding tube segments end-to-end to form a composed tube, which welding apparatus is arranged to rotate substantially jointly with the tube to be moved in the borehole.
- 30 23. A device according to claim 22, characterised in that it is provided with means for surface treatment of the inner and/or outer surface of the tube to be inserted.

24. A device according to claim 22 or 23, characterised in that it is provided with means for aligning and positioning tube ends to be connected.

- 5 25. A packer for sealing a tube and arranged to rotate substantially jointly therewith, comprising connecting means for connecting to a fluid or energy supply, characterised in that said connecting means are arranged to fixedly couple the packer to a flexible fluid or energy supply extending from the fluid source.

REC'D 27 FEB 2002

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT



(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P50938PC00	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/NL99/00586	International filing date (day/month/year) 21/09/1999	Priority date (day/month/year) [21/09/1999]
International Patent Classification (IPC) or national classification and IPC E21B3/025		
Applicant WELL ENGINEERING PARTNERS B.V. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 6 sheets, including this cover sheet.  
  
☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).  
  
 These annexes consist of a total of 6 sheets.

3. This report contains indications relating to the following items:

- |      |                                     |   |
|------|-------------------------------------|---|
| I    | <input checked="" type="checkbox"/> | Basis of the report   |
| II   | <input type="checkbox"/>            | Priority  |
| III  | <input checked="" type="checkbox"/> | Non-establishment of opinion with regard to novelty, inventive step and industrial applicability  |
| IV   | <input type="checkbox"/>            | Lack of unity of invention  |
| V    | <input checked="" type="checkbox"/> | Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement |
| VI   | <input type="checkbox"/>            | Certain documents cited   |
| VII  | <input checked="" type="checkbox"/> | Certain defects in the international application  |
| VIII | <input checked="" type="checkbox"/> | Certain observations on the international application   |

Date of submission of the demand 20/04/2001	Date of completion of this report 17.01.2002
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Manolache, I Telephone No. +49 89 2399 2065 

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL99/00586

## I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

### Description, pages:

2-17	as originally filed	
1,1a	with telefax of	30/11/2001

### Claims, No.:

1-25	with telefax of	30/11/2001
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### Drawings, sheets:

1/5-5/5	as originally filed
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2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:



**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/NL99/00586

- ☐ the description, pages:
- ☐ the claims, Nos.:
- ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**III. Non-establishment of opinion with regard to novelty, inventive step and industrial applicability**

1. The questions whether the claimed invention appears to be novel, to involve an inventive step (to be non-obvious), or to be industrially applicable have not been examined in respect of:

- ☐ the entire international application.
- ☒ claims Nos. 11-18, 22-25.

because:

- ☐ the said international application, or the said claims Nos. relate to the following subject matter which does not require an international preliminary examination (*specify*):
- ☐ the description, claims or drawings (*indicate particular elements below*) or said claims Nos. are so unclear that no meaningful opinion could be formed (*specify*):
- ☐ the claims, or said claims Nos. are so inadequately supported by the description that no meaningful opinion could be formed.
- ☒ no international search report has been established for the said claims Nos. 11-18, 22-25.

2. A meaningful international preliminary examination cannot be carried out due to the failure of the nucleotide and/or amino acid sequence listing to comply with the standard provided for in Annex C of the Administrative Instructions:

- ☐ the written form has not been furnished or does not comply with the standard.
- ☐ the computer readable form has not been furnished or does not comply with the standard.

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NL99/00586

## 1. Statement

Novelty (N)	Yes:	Claims	1-10, 19-21
	No:	Claims	
Inventive step (IS)	Yes:	Claims	
	No:	Claims	1-10, 19-21
Industrial applicability (IA)	Yes:	Claims	1-10, 19-21
	No:	Claims	

## 2. Citations and explanations **see separate sheet**

## VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

## VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/NL99/00586

**POINT V**

1. The assessment of novelty and inventive step is done under the assumption that the deficiencies mentioned under Point VIII have been waived.
2. With regard to independent claim 1 and corresponding apparatus claim 19, document D2: GB-A-596 715 which is considered the most relevant state of the art discloses a method for axially moving a tube (fig. 1: (A1-A4)) in a borehole in the ground wherein the tube is moved simultaneously along and about its axis (page 2, lines 81-86) and wherein a drill (fig. 1: (B)) is used of which the rate of material removal is independent of the direction or speed of rotation of the tube about its axis (fig. 1, see the disposal of the drill bit tooth) wherein the tube is moved about its axis in a series of alternating, angularly opposite, rotating movements within a limited angular range of rotation ( page 2, lines 84-86). The further features of claim 1 are new and the claim meets therefore the novelty requirement of Art 33(2) PCT.  
From this disclosure the subject-matter of claim 1 and 19 (under the remarks of Point V. 1) differs in that a drive mechanism for the drilling bit is connected to the tube and is rotated jointly with the tube. However this is a conventional feature well known from directional drilling. Therefore its application to D2 does not imply an inventive step in the meaning of Art. 33(3) PCT.
3. The distinguishing features of claim 2, 3 and 20 consists in a wide range of values for angle delimiting an alternative rotation and the corresponding rotation times, values which can not be considered as implementing an inventive step.
4. The additionally specified feature of claim 4 is a method that the person skilled in the art would employ in alternating angularly opposite drilling in order to maximize the efficiency transmitting the torque to the tube and accordingly to the drive mechanism and drilling bit. This claim also does not meet the requirements of Art. 33(3) PCT.
5. The distinguishing feature of claim 5 is normal procedure for the person skilled in the art during RIH or POOH operations when difficulties like key seat, differential sticking, high dog leg appear. Therefore this claim does not meet the requirements of Art 33(3) PCT.
6. The distinguishing features of claims 6, 7, 8 and 9 have already been employed in D2 (claim 1).

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**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/NL99/00586

- 1) for the same purpose of insuring the rigidity of the joint connections of the tubing. Therefore the subject-matter of these claims does not comply with requirements of Art. 33(3) PCT.
7. The distinguishing feature of claim 10 has also been employed in D2 (page 1, lines 83-89) for the same purpose of casing while drilling. Also the subject-matter of this claim is not inventive.
8. The distinguishing feature of claim 21 is a normal design used in conventional rotary drilling. Therefore this claim also does not meet the requirements of Art. 33(3) PCT.

**POINT VII**

If the applicant files amended claims, two-part form of the independent claims 1 and 19 with regard to D2 in compliance with rule 6.3(b)(ii)PCT is suggested.

**POINT VIII**

Further deficiencies under the terms of Art. 6 are pointed out:

1. From independent claim 19 it appears that an essential technical feature which makes the intended limitations clear is that the drive is carried on a bottom most part of the tube. However this feature is missing from claim 1, leaving open the paradoxical possibility that the drive is on the surface, rotating with the tube on a rotary table. Therefore this feature should have appeared also in claim 1.
2. In the examination of this application, the wording of claims 1 (line 5), has been read as "...drive mechanism for the drill is connected to the **tube** and....", and the wording of claim 19 (line 1) as "...connections for connecting the **tube** to drive mechanism...". The above specification has been made in order to adapt the claims to the disclosure and to the technical phenomena and should have appeared in claims 1, 19.

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new page 1

Title: Method and device for moving a tube in a borehole in the ground

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to a method for axially moving a tube in a borehole in the ground according to the introductory portion of claim 1. The invention further relates to a device for axially moving a tube into a borehole in the ground according to the introductory portion of claim 19.

GB 591 922 and GB 596 715 disclose a method for axially moving a tube carrying a drill in a borehole in the ground, wherein the tube is moved simultaneously along and about its axis in a series of alternating, angularly opposite, rotating movements within a limited angular range of rotation of less than 180°.

Methods and devices according to the preamble of claims 1 and 19 are known from practice, for instance for axially inserting a tube in a borehole or for axially retracting tube from a borehole. Such a tube may be used for the drilling process and simultaneously for the protection of the newly drilled wellbore. This technique is commonly referred to in the field as casing drilling. Such a borehole can be used for extracting oil or gas and for other purposes, such as for the extraction of salt or geothermal energy and also for civil engineering purposes such as laying pipelines under rivers.

When using the known methods and devices, usually a first tube part is inserted into a borehole in the ground provided by a drill. Subsequently further tube parts are coupled to the upper end of the tube reaching into the

borehole, e.g. via a screw and/or clamp coupling. As the tube is introduced further into the ground, successive tube parts, which can each be composed of one or more pre-connected tube joints, are connected to the proximal end of the composed section of the tube end projecting from the ground until the tube has reached its final length. When the tube is removed, this method is essentially reversed.

Int. pat. appln. no. PCT/NL99/00586  
Our letter of November 2, 2001

### New claims

1. A method for axially moving a tube (1) in a borehole (2) in the ground (3), wherein the tube (1) is moved simultaneously along and about its axis (A) and wherein a drill (5) is used of which the rate of material removal is independent of the direction or speed of rotation of the tube (1) about its axis (A), and wherein a  
5 drive mechanism (6) for the drill (5) is connected to the ground (3) and is rotated jointly with the tube (1) characterised in that the tube (1) is moved about its axis (A) in a series of alternating, angularly opposite, rotating movements within a limited angular range of rotation, the angular range comprising at least one full rotation of 360°.
- 10 2. A method according to claim 1, characterised in that the limited angular range of rotation is preselected to comprise comprises less than 1800°, preferably less than 1080°, in particular less than 720°.
3. A method according to claim 1 or 2, characterised in that the time  
15 needed to complete two consecutive, alternating angularly opposite rotating movements is at least 10 s, preferably at least 20 s.
4. A method according to claim 1 or 2, characterised in that the  
frequency of alternating angularly opposite rotating movements is such that an oscillation is generated that corresponds to the base or higher order natural frequency of the tube (1).
- 20 5. A method according to any of claims 1-4, wherein a series of alternating, angularly opposite, rotating movements within the pre-selected angular range of rotation is preceded and/or succeeded by a non-oscillating, continuous rotating movement about its axis (A).
6. A method according to any of claims 1-5, characterised in that said  
25 tube (1) is composed by connecting successive tube parts (4a,4b) rotationally rigid end-to-end.

7. A method according to claim 6, characterised in that tube parts (4a,4b) are connected end-to-end by welding.
8. A method according to claim 6 or 7, characterised in that said tube parts (4a,4b) are connected while axially inserting the tube (1) into the
- 5 borehole (2).
9. A method according to any of claims 1-8, characterised in that the tube (1) is axially moved into the borehole (2) in the ground (3) to form a casing for a borehole (2).
10. A method according to claim 9, wherein the tube (1) is inserted while a
- 10 borehole (2) is being drilled by a drill (5).
11. A method according to any of the previous claims, characterised in that the pre-selected angular range of rotation includes less than 360°, preferably less than 180° to remove ground in a circular segment at the tube end, such that, when the tube (1) is axially advanced into the borehole (2), a tip
- 15 of the tube (1) is advanced along a curved path.
12. A method according to any of the preceding claims, characterised in that the torque exerted on the tube (1) at the surface (7) is measured while performing angularly symmetrical opposite, rotating movements within the pre-selected angular range to determine a mid-point of lower torque values.
- 20 13. A method according to any one of the preceding claims, characterised in that relative angular orientation of tube sections axially spaced apart is monitored.
14. A method according to claim 13, characterised in that said monitoring includes observing an axial line provided on the outside of the tube (1).
- 25 15. A method according to claim 13, characterised in that said monitoring includes detecting angular orientations of axially spaced magnetic markings on the outside of the tube (1).
16. A method according to claim 15, characterised in that said series of alternating, angularly opposite, rotating movements have an azimuth at the



17. A method according to claim 16, characterised in that a an alternating torque having an azimuth is exerted to said tube (1), said azimuth at the tube tip being further controlled in response to the orientation of the tube (1) in the area of the ground surface (7) when said azimuth of said torque occurs.

18. A method according to any one of the preceding claims characterised in that pumping of mud is continued while a connection with a next tube section is being made via a hose (14) and packer (16) combination which sealingly connects to the tube section in the hole.

19. A device for axially moving a tube (1) in a borehole (2) in the ground (3), comprising means for moving the tube (1) along and about its axis (A) and connections for connecting the ground (3) to a drive mechanism (6) for a drill (5) carried on a bottom most part of the tube (1) and rotating jointly with the tub  
15 (1), characterised in that the means for moving the tube (1) about its axis (A) comprises a rotational drive that is arranged to drive the tube (1) to rotate about its axis (A) in at least one full rotation and that is operatively coupled to control means (30) for controlling the drive to perform alternating, angularly  
20 opposite, rotating movements within a limited angular range of rotation, the angular range comprising at least one full rotation of 360°.

20. A device according to claim 19, characterised in that the limited angular range of rotation is preselected to comprise less than 1800°, preferably less than 1080°, in particular less than 720°.

21. A device according to claims 19 or 20, characterised in that the  
25 rotational drive and the control means (30) are further configured to selectively  
control the drive to perform a continuous, non-alternating, rotating movement.

22. A device according to any of claims 19-21, characterised in that it comprises a welding apparatus for welding tube segments end-to-end to form a composed tube, which welding apparatus is arranged to rotate substantially jointly with the tube (1) to be moved in the borehole (2).

23. A device according to claim 22, characterised in that it is provided with means for surface treatment of the inner and/or outer surface (7) of the tube (1) to be inserted.

24. A device according to claim 22 or 23, characterised in that it is provided with means for aligning and positioning tube ends to be connected.

25. A packer (16) for sealing a tube (1) and arranged to rotate substantially jointly therewith, comprising connecting means for connecting to a fluid or energy supply, characterised in that said connecting means are arranged to fixedly couple the packer (16) to a flexible fluid or energy supply extending from the fluid source.

# PATENT COOPERATION TREATY

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NRF<sub>2</sub> 21-5-2002

**PCT**

From the  
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

## NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Copie niet in aan nemen	TERM JA	To:  Mr Ir A.W. Prins, c.s. VEREENIGDE Nieuwe Parklaan 97 NL-2587 BN The Hague PAYS-BAS	Date of mailing (day/month/year) 17.01.2002
		23 JAN 2002	
	Beantwoord Voorl. dat.	Bericht gezonden van 24/1/02	
		Applicant's Agent's file reference P50938PC00	<b>IMPORTANT NOTIFICATION</b>
		International application No. PCT/NL99/00586	International filing date (day/month/year) 21/09/1999
			Priority date (day/month/year) 21/09/1999
		Applicant WELL ENGINEERING PARTNERS B.V. et al.	

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

#### 4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/



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(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
29 March 2001 (29.03.2001)

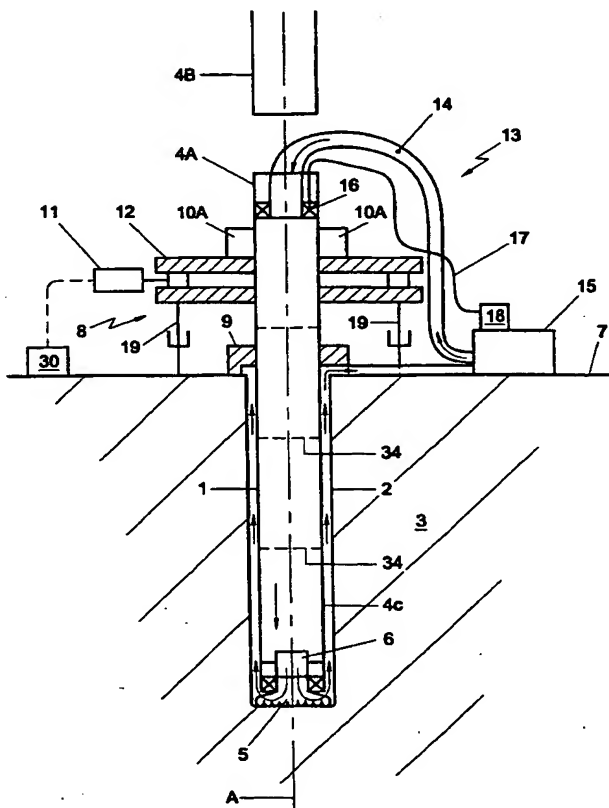
PCT

(10) International Publication Number  
**WO 01/21929 A1**

- (51) International Patent Classification<sup>7</sup>: **E21B 3/025**, 7/24, 21/01, 7/06, 4/20, 19/16
- (21) International Application Number: **PCT/NL99/00586**
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- (71) Applicant (for all designated States except US): **WELL ENGINEERING PARTNERS B.V.** [NL/NL]; Tynaarlosestraat 68, NL-9481 AE Vries (NL).
- (72) Inventor; and
- (75) Inventor/Applicant (for US only): **BAKKER, Thomas**, Walburgis [NL/NL]; Tynaarlosestraat 68, NL-9481 AE Vries (NL).
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(54) Title: METHOD AND DEVICE FOR MOVING A TUBE IN A BOREHOLE IN THE GROUND



(57) Abstract: A method for displacing a tube (1) in a borehole (2) in the ground (3) is disclosed. The tube is simultaneously displaced along and about its axis, such that it is axially introduced into or retracted from the borehole. According to the invention, displacing the composed tube about its axis comprises an oscillating movement. The invention further relates to a device for displacing a tube in a borehole.

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*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

Title: Method and device for moving a tube in a borehole in the ground

#### FIELD AND BACKGROUND OF THE INVENTION

This invention relates to a method for axially moving a tube in a borehole in the ground according to the introductory portion of claim 1. The invention further relates to a device for axially moving a tube into a borehole in the ground according to the introductory portion of claim 19.

Such methods and devices are known from practice, for instance for axially inserting a tube in a borehole or for axially retracting tube from a borehole. Such a tube may be used for the drilling process and simultaneously for the protection of the newly drilled wellbore. This technique is commonly referred to in the field as casing drilling. Such a borehole can be used for extracting oil or gas and for other purposes, such as for the extraction of salt or geothermal energy and also for civil engineering purposes such as laying pipelines under rivers.

When using the known methods and devices, usually a first tube part is inserted into a borehole in the ground provided by a drill. Subsequently further tube parts are coupled to the upper end of the tube reaching into the borehole, e.g. via a screw and/or clamp coupling. As the tube is introduced further into the ground, successive tube parts, which can each be composed of one or more pre-connected tube joints, are connected to the proximal end of the composed section of the tube end projecting from the ground until the tube has reached its final length. When the tube is removed, this method is essentially reversed.

During insertion or retraction the composed tube is driven to rotate about its axis in a fixed direction, such that continuous rotation is achieved. This is done to provide

the frictional force between the tube and its surroundings with a tangential component, thus reducing the axial frictional component, which substantially decreases the axial force needed to insert or retract the composed tube into or from the borehole. It shall be clear that also a single length of tube can be used instead of connected tube parts.

A disadvantage of the known method and device for axially moving a tube in this manner is that, due to the continuous rotation of the tube, it is a problem to provide solid-state, safe connections between the stationary ground and apparatuses rotating jointly or solidarily with the tube. In particular, during drilling operations a swivel connecting the tube to a mud supply is to be provided with an elaborate rotational seal. The same holds true for e.g. hydraulic connections to a drill carried on the tube or pneumatic connections to a packer connected to the tube. In particular, providing a spark-free electrical connection between devices rotating substantially jointly with the tube and the ground in the often explosion endangered environment near a borehole has proven to be a problem.

In practice, due to the problem of providing a reliable connection, often the rotation is stopped, when e.g. a drill needs to be retracted or when an inspection apparatus has to be lowered. This greatly increases the risk of the tube getting stuck due to settling of the ground or due to a phenomenon known in the field as differential sticking.

In the currently known art of casing drilling, the direction of the tube is controlled by devices protruding from the lower end of the tube. The application of such devices is costly and the measure of control is limited. As such it is currently not feasible to apply casing drilling for high angle or near horizontal holes.

## SUMMARY OF THE INVENTION

It is an object of the invention to circumvent, at least to a considerable extent, the drawbacks associated with the above method and device.

This object is achieved according to the present invention by carrying out a method for axially moving a tube in a borehole in the lithosphere in accordance with claim 1. The invention further provides a device according to claim 19 which is specifically adapted for carrying out such a method.

By twisting the tube about its axis in a series of alternating, angularly opposite, rotating movements within a limited angular range of rotation, it is possible to use relatively simple, flexible connections extending between fixed couplings to provide a connection between devices rotating jointly or solidarily with the composed tube and the stationary ground. An example of such a flexible connection extending between fixed couplings is e.g. a length of flexible hose or pipe fixed with simple clamps on each end for fluid connections or a length of insulated cable provided with plugs on each end for co-operation with sockets to provide an electrical connection.

The limited rotational angle of this "oscillating" rotational movement will prevent the flexible connections from becoming wound-up too far as would be the case with an increasing rotational angle caused by the rotational movement of the prior art.

Furthermore, during insertion or retraction of a device, e.g. a drill, a packer, a sensor or an inspection apparatus, through the inside of the tube, the tube can be oscillated continuously, thus greatly reducing the risk of the tube getting stuck.

The angular range of rotation can be preselected to comprise approximately one full rotation of 360°, e.g. ranging from - 180° to + 180° or 0° to 360°. The range can also



comprise more than one full rotation, i.e. include an angle of more than  $360^\circ$  in e.g. the interval from  $0^\circ$  to  $720^\circ$  or  $-360^\circ$  to  $+360^\circ$  or a multiple of this angle or less than one full rotation, e.g.  $0^\circ$  to  $180^\circ$  or  $-90^\circ$  to  $+90^\circ$ . Preferably, less than 5 full rotations in one direction, e.g. left hand rotations, are followed by the same number of full rotations in the opposite direction, e.g. right hand rotations.

The oscillating movement can be such that each alternating angular movement is substantially equal in magnitude, such as to achieve a symmetric pattern. However, it is also possible to perform a series of alternating rotating movements that are not equal in magnitude, e.g. a series of alternating movements that provide a gradual angular drift which may have an oscillating pattern so that the total angle of rotation remains within a limited angular range at all times or be a drift in one sense so that the total angle of rotation remains within a limited angular range for a limited duration only. Such a duration may for instance be of sufficient length to perform operation on or with the tube, such as steering the drilling direction or connecting an end of tube material to the tube.

It shall be clear that within this context the rotational angle within the pre-selected angular range is defined as an absolute angle of rotation of the tube about its axis, relative to the ground.

Furthermore, it shall be clear that when axially moving the tube, a first series of alternating angularly opposite rotating movements performed within a first pre-selected angular range of rotation can be followed by a second series of such movements within a second range.

The frequency of the opposite movements or oscillations is preferably less than several oscillations per minute, typically less than 10 oscillations per minute and/or can be chosen to match the natural frequency of the tube in the ground. In the proposed method the oscillations are preferably performed at 0,1 or 0,05 Hz. The method however

does not exclude the application of a higher frequency of oscillation, e.g. in a typical range from 1 to 50 HZ.

In another advantageous embodiment of the invention a welding or cutting apparatus oscillates substantially jointly or in unison with a composed tube and a rotating tube part to be connected therewith, respectively to be cut therefrom. This enables continuous insertion or retraction of the tube into/from the borehole, as will be elucidated further. It should be noted that welded or other rotationally rigid connections between the successive tube parts are especially advantageous in view of their increased resistance to become undone by the angularly opposite rotational movements compared to the screw connections generally used to couple successive casing or tubing parts. The rotationally rigid connections between the tube elements allow precise control of the relative orientation of the tube end below the surface and the tube part visible at the surface. The use of an axial line provided on the outside of the tube, e.g. by inscription, and precise measurement of the angle between the line on each consecutive tube section will provide an exact knowledge of the orientation of tube end below the surface.

By measuring the torque exerted on the tube at the surface while performing angularly symmetric oscillations, a mid-point position can be determined, characterised by the mid-point of the lower torque values. The azimuth of this mid-point position relative to the azimuth of the inscribed line is indicative for the azimuth of the tube end. The tube end azimuth determined in this way can be corrected for the reactive torque of the drilling tool suspended in the tube end, if necessary.

Another important advantage of the consecutive angularly opposite movement is that, by performing the consecutive movements within a circle segment, a tube having a bent tip can be steered while inserting it axially into the ground. Instead of a bent tip, it is also possible to use other kinds of devices standing-off asymmetrically from the

axis A at the end of the tube tip. In order to change the direction of the borehole to be drilled, i.e. the azimuth and angle of the borehole, the oscillating range is chosen to be symmetrical about a predetermined tube end azimuth and to include less than 360° rotation of the tube end, for instance a range from - 45° to + 45°. These small oscillations achieve that the cutting process at the tube end preferentially removes rock or ground in a circle segment corresponding to the desired hole direction. This process is continued until the desired tube end hole angle in the desired tube end azimuth is achieved. In order to continue the borehole at the same hole angle in the desired tube end azimuth, the oscillations and rotation are adjusted such that the cutting process at the tube end removes equal amounts of rock in all directions. The borehole can thus be steered in the desired direction using surface measurements based on the azimuth of the line and inclination measurements at the tube end. Preferably, a drill is used of which the rate of material removal is independent of the direction or speed of rotation, e.g. a hydraulically powered chisel.

In addition, by providing a mud chamber fixedly connected to a mud supply by means of two flexible hoses, the supply of mud can be continued while tube parts are added to a tube or are separated therefrom.

Particularly advantageous elaborations of the invention are set forth in the dependent claims. Further objects, elaborations, effects and details of the invention appear from the following description, in which reference is made to the drawing.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematical cross-section of a casing 1 being inserted in a borehole;

Fig. 2 is a schematical cross-section of a apparatus for composing a casing from casing parts and inserting the

composed casing in a borehole, while simultaneously drilling the borehole;

Fig. 2A is a schematical diagram of yet another embodiment of an apparatus for composing a casing from casing parts and inserting the composed casing in a borehole;

Figs. 3A-E show a mud chamber for providing continuous mud flow while drilling in various stages of operation;

Fig. 4 shows a lower most casing part with a bent tip or for directional drilling; and

Fig. 5 shows a circular segment corresponding to an pre-selected angular range of rotation for directional drilling.

#### DETAILED DESCRIPTION

Although the exemplary elaborations discussed below generally relate to composing and inserting a casing into a borehole in the ground by means of a casing drilling process, wherein the tube to be inserted carries a drill, similar elaborations can also be applied to insertion of other types of (composed) tubes into a borehole in the ground or retracting such tubes from such a borehole, which tubes need not carry a drill.

Fig. 1 shows a tubular casing 1 which is introduced into a borehole 2 in the ground 3. The casing 1 is composed by connecting successive tubular casing parts 4, e.g. 4A and 4B end-to-end. The first or bottom most casing part 4C carries a collapsable drill 5 having an outer diameter slightly larger than the diameter of the casing parts. The drill 5 is driven by a mud motor 6, which is in turn powered by means of a high-pressure flow of mud induced through the inside of the casing 1. The drill can e.g. comprise a so-called collapsable crushing or gauging drilling bit for removing rock. After passing through the mud motor 6, the mud emerges from the casing 1 at the location of the drill 5 and

washes upwards to the surface 7 between the outer diameter of the casing 1 and the walls of the borehole 2. In the drawing, the flow path is shown with arrows.

It shall be noted that instead of a drill 5 comprising a mud motor/bit combination, a mud hammer assembly with a collapsible chisel type bit can be applied, alternatively high pressure jetting assembly can be applied for rock removal. Instead of powering the drill, hammer or jetting assembly with hydraulic energy, electrical or pneumatic drive mechanisms may also be applied.

It shall also be noted that to ensure that the diameter of the hole 2 is sufficiently large for the casing 1, a cutting structure may be applied to the outside of the tube tip, specifically adapted for operating with an oscillating motion of the tube tip.

The casing 1 is axially advanced along its axis A into the borehole 2 by means of a drilling table 8 mounted above the well head 9, which can include a usual blowout preventor. The well head 9, including the blowout preventor is placed on the surface 7 to seal the area between the casing 1 and the borehole 2.

The drilling table 8 is mounted on leg structures 19 of which the effective length can be changed, e.g. by means of hydraulic cylinders. The drilling table 8 is provided with grippers 10A frictionally engaging the outer circumference of the proximal end of the casing 1 projecting from the borehole 2 beyond the surface 7. These grippers are capable of supporting the full weight of the tube plus the upward friction and transmitting left and right hand torque to the tube to a maximum of the torsional strength limit of the tube. As the drill 5 cuts through the ground 3, the casing 1 is advanced axially along its axis A into the borehole 2 by decreasing the length of the legs 10. To decrease the friction in axial direction between the casing 1 and the borehole 2, the casing is moved about its axis A in a series

of alternating, angularly opposite rotating movements within a pre-selected angular range of rotation.

The consecutive, angularly opposite, rotating movement is for instance performed by firstly rotating the casing 1080° clockwise about its axis relative to the ground, followed by a countering rotation of 1080° counter clockwise, followed by a clockwise rotation of 1080° and so on. Thus, an oscillating movement is performed within a pre-selected range of 0° - 1080°. It shall be clear that it is also possible to start off with a first rotation of e.g. half or double the angle  $\alpha$  of the countering movement. Also, it shall be clear that it may be possible to perform consecutive, angularly opposite rotating movements having angular values  $\alpha$  that are not equal in size and still remain within the pre-selected range, at least during a preselected time interval

The oscillating movement is generated by control means 30 controlling a motor 11 which drives a rotationally disposed upper portion 12 of the drilling table 8 to rotate in consecutive, angularly opposite rotational movements. The upper portion in turn carries the clamps or grippers 10A for transmitting torque between the upper portion 12 and the casing 1. It shall be clear the entire leg structure 19 may be supported such that it oscillates as one unit. The amount of time needed to perform the two consecutive opposite angular movements is e.g. 10 sec., corresponding with a frequency of oscillation of 0,1 Hz.

It is also possible to vary the time of a full oscillation cycle during the course of inserting the tube in order, for instance to adapt the oscillating frequency to changes in the length and natural frequency of the tube or to requirements brought about by operations to be performed with or on the tube, such as connecting a next end of tube material or steering the tip of the tube into a different direction.

As is clear from fig. 1, the mud supply line 13 comprises a simple, solid-state and safe connection between

the surface 7 and the oscillating casing 1. The mud supply 13 comprises a flexible hose 14 that is fixedly connected to the mud pump 15 by means of clamps on one end and that is fixedly connected by clamps to a packer 16 rotating jointly with the casing 1 on the other end. Due to the fact that the absolute angle  $\alpha$  of axial rotation of the casing remains within the pre-selected range, the flexible hose 14 between the mud pump 15 and the packer 16 will not wind up and a rotational seal, called swivel by those skilled in the art, need not be provided.

Furthermore, it is also possible to provide hydraulic, pneumatic and/or electric connections in the same fashion, e.g. flexible hydraulic hoses 17 for operating the packer 16, which are rigidly connected to the packer 16 on the one end and to a hydraulic pressure source 18 on the other end.

As will be clear, during insertion or retraction of the casing 1, the oscillating movement is performed simultaneously with the axial movement. However, when axial displacement of the casing is not necessary, e.g. while the mud motor 6 and/or the drill 5 is retracted, the oscillating movement can be continued, thereby greatly reducing the chance of the casing 1 getting stuck in the borehole 2. In operation, the casing 1 will act as a torsional spring, thereby assisting the motor 11 in driving the casing to oscillate.

Referring to fig. 2 it is shown that in a further embodiment of the invention, in order to decrease down-time and in order to enable continuous insertion of a composed casing 1 into the borehole 2, a second drilling table 20 is provided. This drilling table is of similar construction as the drilling table 8 and is also provided with hydraulically adjustable legs 21, a rotationally disposed upper portion 22 driven by a motor 23 and carrying clamps 24.

The second drilling table 20 also carries guiding means 25 in which a casing part 4B can be inserted, such that

it is axially aligned with the proximal end of the casing 1 projecting from the borehole and can be synchronised in axial oscillation therewith by drives 31, operatively coupled to control means 30. When the tube parts 4A, 4B are disposed end-to-end they can be welded together by means of a welding apparatus 26 disposed on the upper portion 22 of the second drilling table 20, such that it can rotate substantially jointly with the casing 1. Due to the oscillating movement within the pre-selected angular range, the electrical connections 33 between the surface 7 and the welding apparatus 26 can be configured as cables with plugs on each end, while the need for a commutator is obviated. The welding apparatus 26 is disposed within a neutral-gas environment extending both on the radial outside of the casing 1 and the casing part 4B to be connected therewith and on the radial inside thereof. On the radial outside, the neutral gas environment is provided as a chamber 28, while on the radial inside the neutral gas environment is e.g. provided by means of a seal 34, cooperating with the packer 16 to form a chamber 29, such as to create an explosion proof environment for the welding or cutting process. Instead of neutral gas, the welding chamber and the annular space of the tube part to be connected may be flushed with air from a secure source such as to eliminate explosion hazards.

The welding apparatus is arranged to rotate about the axis A of the casing, such that a circular weld 34 can be provided between the tube parts.

Preferably, the length of the tube parts 4A, 4B, 4C is chosen in relation to the speed of synchronisation and welding, such that at full speed of insertion, a successive tube part 4B can be connected to the casing 1 before axial insertion of a tube segment is completed. It should be noted that, in order to enable constant axial insertion, the drilling tables 8 and 20 are arranged to cooperate in a relay fashion, such that at any time at least one drilling table rotationally drives the casing and simultaneously inserts the



casing axially into the borehole 2, while the other drilling table stretches its legs. Both tables 8 and 20 may be combined in one unit which oscillates as one assembly. As the tube parts are driven on the radial outside, the motors 11, 23 can be placed relatively close to the surface 7 and a top-drive can be omitted. This way, the casing parts can be hoisted into the guiding means 25 with a conventional crane and a rig structure need not be built.

In an other embodiment of the invention shown in fig. 2A the welding or cutting process is not combined with an upper table 20 to keep the leg structure compact, e.g. with a stroke of typically less than 3 meters. The welding or cutting process in this embodiment is contained in a welding apparatus 26A that is clamped to the tube 1 by means of clamps 26B and comprises alignment means for aligning tube section 4B. The welding apparatus 26A can be moved axially along the tube 1. The table 8A is rotationally disposed on the blowout preventor 9A and allows axial insertion, while the clamps 10B are provided with to retain the tube while the legs 19A are stretched in an upward stroke.

It shall be clear that it is also possible to axially retract the casing 1 from the borehole 2 using the apparatus of figs. 2 and 2A. In this case, instead of a welding apparatus 26, 26A an abrasive cutter or any known cutting process can be installed.

It shall be noted that means may be provided on e.g. the welding apparatus to post-weld heat-treat the connection.

It shall be noted that in addition means may be provided, e.g. on the assembly of hose 14 and packer 16, to remove excess material from the inside of the weld zone. Such means may be configured to fully smoothen or polish the inside of the weld zone. Advantageously, such means are configured to smoothen or polish the entire inside of tube section 4B or to cover it with a coating.

It shall be noted that the assembly of hose 14 and packer 16 may include devices to properly internally align

the tube end protruding from the hole (4A) and the new tube section 4B. Such alignment device may also be integrated with the welding apparatus.

5 It shall be noted that the welding apparatus may be provided with any type of tools to remove excess welding material and smoothen or polish the outside of the weld zone. This functionality may also be extended such that the entire outside of tube section 4B can be smoothened or polished or covered with a coating.

10 It shall be clear that it is possible to configure only selected sub-elements of the system to oscillate. The composition of the system can e.g. be such that for example welding or cutting and the replacement of the drilling tools can take place in an oscillating mode, while during normal  
15 drilling continuous right or left hand rotation can be performed. In this case a swivel would e.g. be applied with a rotating seal for the mud supply hose. In general, any combination of oscillating and rotating modes can be selected to improve the drilling performance, optimise the design of  
20 the equipment etc. In particular, the method may include oscillating rotating movements while welding and/or steering, and continuous rotating movements while drilling.

The constructional details of the drilling table will not be described in detail, many ways of realising the  
25 construction will be apparent to the skilled man. For further detail reference is made to international patent applications WO 99/34089, WO 99/34091 and PCT/NL 98/00597.

It should be noted that it is also possible to provide the motors 11, 23 with means for accumulating energy,  
30 e.g. a fly wheel or springs, in order to assist the motors 11, 23 when the angular rotational movement is reversed.

It shall be clear that the drilling tables can be used advantageously by themselves. In particular, the rotationally disposed table with the grippers 10 and the  
35 motor 11 provided with control means 30 to induce alternating, angularly opposite rotating movements can by

themselves be used to drive a tube or a casing to oscillate, thus reducing the chance of the tube getting stuck in a borehole.

Referring to figs. 3A-E it is elucidated how, due to the oscillating movement, the mud supply can be continued while successive casing parts are connected. Fig. 3A shows that the packer 16 is connected to the flexible hose 14 of the mud supply 13 by means of quick connect coupling 41. When a subsequent casing part 4B is to be connected to the uppermost casing part 4A, a mud chamber 42 is placed on the upper portion of the casing part 4A as shown in fig. 3B. This mud chamber 42 may or may not be part of the structure housing the welding or cutting process. The mud chamber 42 is provided with a side entry 43 where a secondary flexible hose 14A is fixedly connected to the mud chamber 42, e.g. by means of a clamp connection. As the mud chamber 42 oscillates jointly with the casing, the connection between the mud chamber 42 and the mud pump 15 can be a simple flexible connection. The mud chamber 42 furthermore comprises seals 44 for sealingly connecting it to the casing 1. The mud chamber 42 further comprises an adjustable seal 45, e.g. an hydraulically actuatable diaphragm through which the flexible hose 14A can pass sealingly.

As a first step, the mud chamber 42 is axially moved upwards (fig. 3B) and the mud supply 13 is adjusted to feed mud through the secondary flexible hose 14A, while the supply through the flexible hose 14 is cut (fig. 3C). This can be performed by a set of suitable valves. The mud flow is indicated with arrows P and P1. Simultaneously, the packer 16 is released, e.g. by hydraulic operation, and is retracted via the flexible hose 14 until it is located in the mud chamber 43 near the adjustable seal 45.

Subsequently, the flexible hose 14 is released from the quick connect coupling 41 and is axially fed through the casing part 4B that is to be connected to the casing part 4A. Next, the quick connect coupling 41 is reconnected and the

next casing part 4B is placed (fig. 3D). The packer 16 is then lowered into the casing part 4A, as is shown in fig. 3E. When the packer 16 is in place, it is actuated to sealingly engage the inner portion of the casing part 4A, while  
5 simultaneously the mud flow is transferred from the secondary flexible hose 14A back to the flexible hose 14. The mud chamber 42 can now be moved axially upward onto the casing section 4B, leaving the abutting edges of the casing parts 4A and 4B free to be welded. After the weld has been realised,  
10 the packer 16 can be moved axially upwards, thereby completing the operating cycle 4B.

Alternative methods of inserting casing section 4B includes the pre-installation of hose 14 and packer 16 in the casing 14 to be connected. The mud chamber 42 would then be  
15 constructed in such a way that hose 14 and packer 16 can be completely removed from the tube end 4A, and that section 4B including the pre-installed hose 14 and packer 16 assembly can be installed.

The constructional details of the mud chamber 42, the  
20 seals 44, 45, the packer 16, the quick connect coupling 41 and the valves needed to direct the mud flow through the flexible hoses are known to the skilled man. In particular a number of advantageous constructive details of the mud chamber are discussed in PCT/NL/98/00597. It should be noted  
25 that the method of providing a continuous mud circulation with the disclosed mud chamber can in itself have many advantageous uses. In particular, the fixed, non-rotating connections between the flexible hoses 14, 14A enable simple and reliable operation.

30 In a further embodiment of the invention during displacement of the tube, a technique is applied which is known as reverse circulation in the field. This technique is particularly suitable for the installation of large diameter casing, typically larger than 13 3/8" OD casing and for  
35 conditions with weak ground formations in an openhole section. With reverse circulation mud is added to the annular

space between the casing that is installed and a previous, usually cemented casing. However the mud may also be added between the casing that is being installed and an inner tube. The return stream of the mud and the formation fragments liberated by the drilling process will then flow via the casing being installed itself or an inner tube which is connected to the drilling process module. The power to drive the drilling process module can be electrically, hydraulically or pneumatically configured. The differential pressure between the mudflow into the annular space and the return flow to surface can be provided by the injection of air or non combustible gas in the return stream, utilising a technique called airlift by those skilled in the art, or by any other means of maintaining a sufficient pressure differential.

Referring to figs. 4 and 5 it is shown how the casing 1 can be used for directional drilling. To this end, the bottom most casing part 4C is provided with a tip portion 51 extending at an angle  $\beta$  relative to the portion 52. For sake of clarity, the angle  $\beta$  has been drawn on an enlarged scale. However, in practice, the angle  $\beta$  can be chosen at a small value, e.g.  $5^\circ$  or less, preferably  $1-3^\circ$ . Alternatively the bottom most casing part may be provided with, for example, devices eccentrically stand-off from the axis A to force the casing from a straight line path. When the bottom most casing part 4C or "sub" is rotated about the longitudinal axis A over a full circular segment, i.e. the angular range of rotation is at least  $360^\circ$ , the casing 1 will advance in a straight line when it is advanced axially into the ground 3. However, when the bottom most casing part 4C is oscillated with alternating, angularly opposite rotating movements within a circular segment, i.e. less than  $360^\circ$  e.g. a range of angular rotation including  $90^\circ$  extending from  $45^\circ$  to  $135^\circ$ , ground is removed in only a part of the circumference at the bottom of the lower-most segment and the casing 1 will follow a curved path when it is advanced into the ground 3.

Especially when a casing 1 is used with a high torsional resistance, e.g. a casing with a large diameter or a casing having a composite structure, e.g. fiber reinforced plastic, the torsional lag between the upper portion of the casing projecting from the surface 7 of the ground 3 and the bottom most portion of the casing carrying the drill 5 will be relatively small, such that a high accuracy can be achieved in directional drilling.

It shall be clear that the bottom most casing part 4C having a tip portion extending at an angle  $\beta$  can also be used for directional drilling of a tube that comprises only one segment or a tube of which the tube parts are connected prior to drilling. It can even be envisaged to perform oscillations within a circular segment with such a casing part during conventional, rotating drilling to change direction.

It shall be clear to the skilled man that the invention is not limited to the preferred embodiments discussed herein and that many aspects of the invention can either be used independently of each other or combined. In particular, the method can be used offshore for seabed drilling. Also, the method can be used during underbalanced conditions. Furthermore, the method can be used for inserting a tube in a predrilled borehole and/or a normal drilling rig may be used. Such embodiments are within the scope of the invention as defined in the appended claims.

Claims

1. A method for axially moving a tube in borehole in the ground, wherein the tube is moved simultaneously along and about its axis, **characterised in that** moving the tube about its axis comprises a series of alternating, angularly  
5 opposite, rotating movements, within a limited angular range of rotation.
2. A method according to claim 1, **characterised in that** the limited angular range of rotation is preselected to comprise comprises less than 1800°, preferably less than 1080°, in  
10 particular less than 720°.
3. A method according to claim 1 or 2, **characterised in that** the time needed to complete two consecutive, alternating angularly opposite rotating movements is at least 10 s, preferably at least 20 s.
- 15 4. A method according to claim 1 or 2, **characterised in that** the time for completing two consecutive, alternating angularly opposite rotating movements is such that an oscillation is generated that corresponds to the base or higher order natural frequency of the tube.
- 20 5. A method according to any of claims 1-4, wherein a series of alternating, angularly opposite, rotating movements within the pre-selected angular range of rotation is preceded and/or succeeded by a non-oscillating, continuous rotating movement about its axis.
- 25 6. A method according to any of claims 1-5, **characterised in that** said tube is composed by connecting successive tube parts rotationally rigid end-to-end.
7. A method according to claim 6, **characterised in that** tube parts are connected end-to-end by welding.

8. A method according to claim 6 or 7, **characterised in that** said tube parts are connected while axially inserting the tube into the borehole.

9. A method according to any of claims 1-8, **characterised in that** the tube is axially moved into the borehole in the ground to form a casing for a borehole..

10. A method according to claim 9, wherein the tube is inserted while a borehole is being drilled by a drill.

11. A method according to any of the previous claims, **characterised in that** the pre-selected angular range of rotation includes less than 360°, preferably less than 180° to remove ground in a circular segment at the tube end, such that, when the tube is axially advanced into the borehole, a tip of the tube is advanced along a curved path.

12. A method according to any of the preceding claims, **characterised in that** the torque exerted on the tube at the surface is measured while performing angularly symmetrical opposite, rotating movements within the pre-selected angular range to determine a mid-point of lower torque values.

13. A method according to any one of the preceding claims, **characterized in that** relative angular orientation of tube sections axially spaced apart is monitored.

14. A method according to claim 13, **characterized in that** said monitoring includes observing an axial line provided on the outside of the tube.

15. A method according to claim 13, **characterized in that** said monitoring includes detecting angular orientations of axially spaced magnetic markings on the outside of the tube.

16. A method according to claim 15, **characterized in that** said series of alternating, angularly opposite, rotating movements have an azimuth at the tube tip, said azimuth at the tube tip being controlled in response to the orientation of the tube in the area of the ground surface.

17. A method according to claim 16, **characterized in that** a



an alternating torque having an azimuth is exerted to said tube, said azimuth at the tube tip being further controlled in response to the orientation of the tube in the area of the ground surface when said azimuth of said torque occurs.

5 18. A method according to any one of the preceding claims **characterised in that** pumping of mud is continued while a connection with a next tube section is being made via a hose and packer combination which sealingly connects to the tube section in the hole.

10 19. A device for axially moving a tube in a borehole in the ground, comprising means for moving the tube along and about its axis, **characterised in that** the means for moving the tube about its axis comprises a rotational drive that is operatively coupled to control means for controlling the  
15 drive to perform alternating, angularly opposite, rotating movements within a limited angular range of rotation.

20 20. A device according to claim 19, **characterised in that** the limited angular range of rotation is preselected to comprise less than 1800°, preferably less than 1080°, in particular less than 720°.

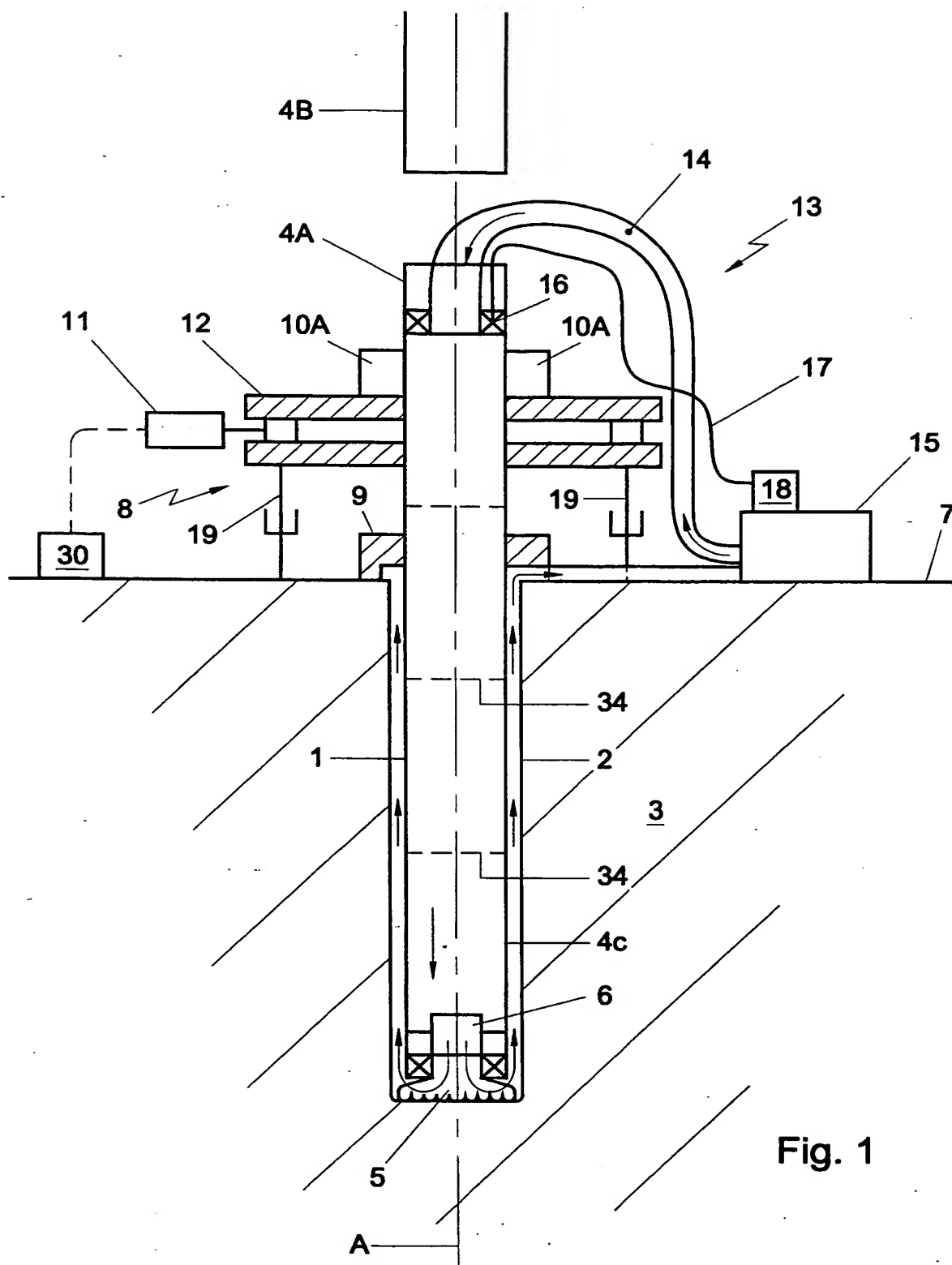
21. A device according to claims 19 or 20, **characterised in that** the rotational drive and the control means are further configured to selectively control the drive to perform a continuous, non-alternating, rotating movement.

25 22. A device according to any of claims 19-21, **characterised in that** it comprises a welding apparatus for welding tube segments end-to-end to form a composed tube, which welding apparatus is arranged to rotate substantially jointly with the tube to be moved in the borehole.

30 23. A device according to claim 22, **characterised in that** it is provided with means for surface treatment of the inner and/or outer surface of the tube to be inserted.

24. A device according to claim 22 or 23, **characterised in that** it is provided with means for aligning and positioning tube ends to be connected.

5 25. A packer for sealing a tube and arranged to rotate substantially jointly therewith, comprising connecting means for connecting to a fluid or energy supply, **characterised in that** said connecting means are arranged to fixedly couple the packer to a flexible fluid or energy supply extending from the fluid source.



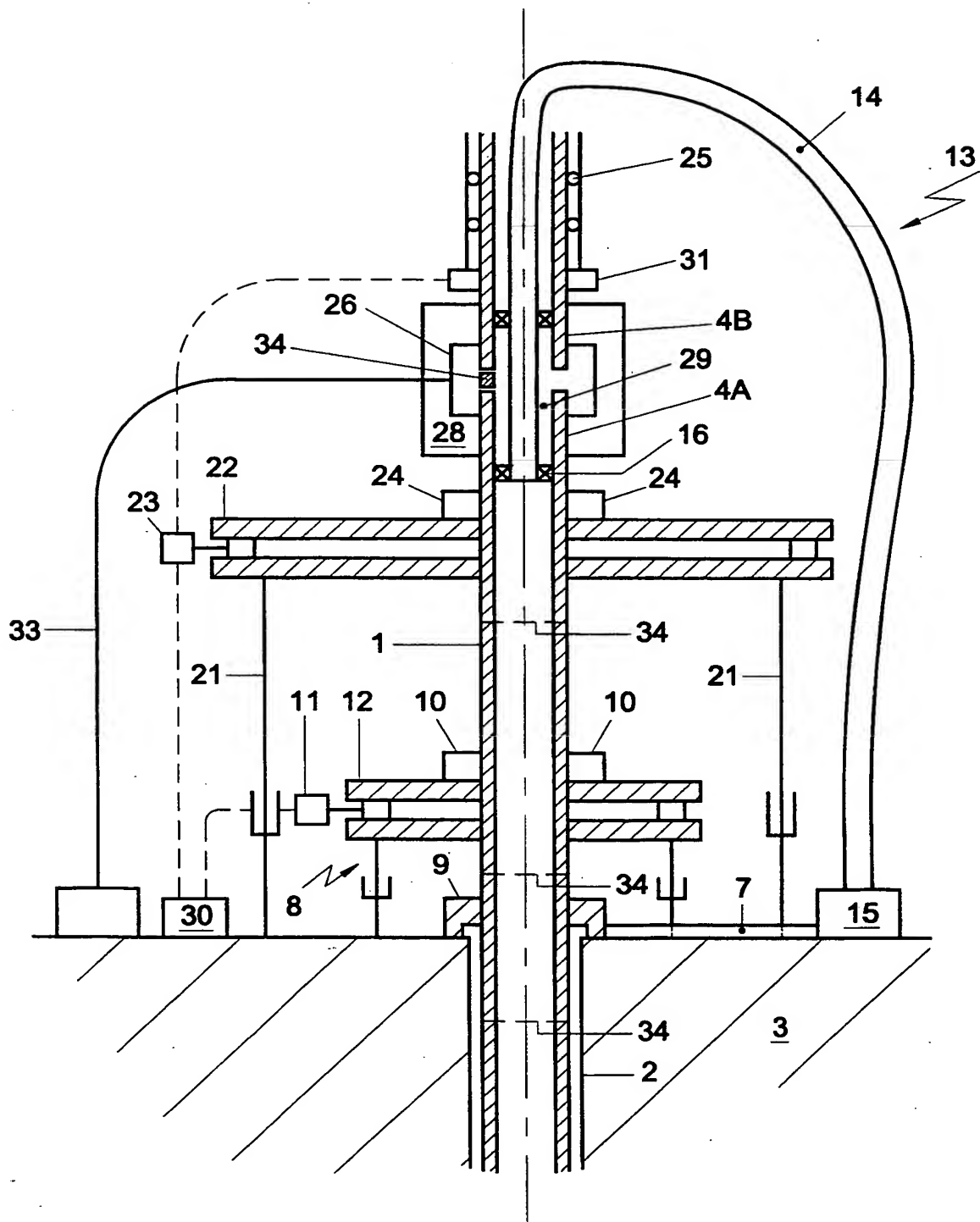


Fig. 2

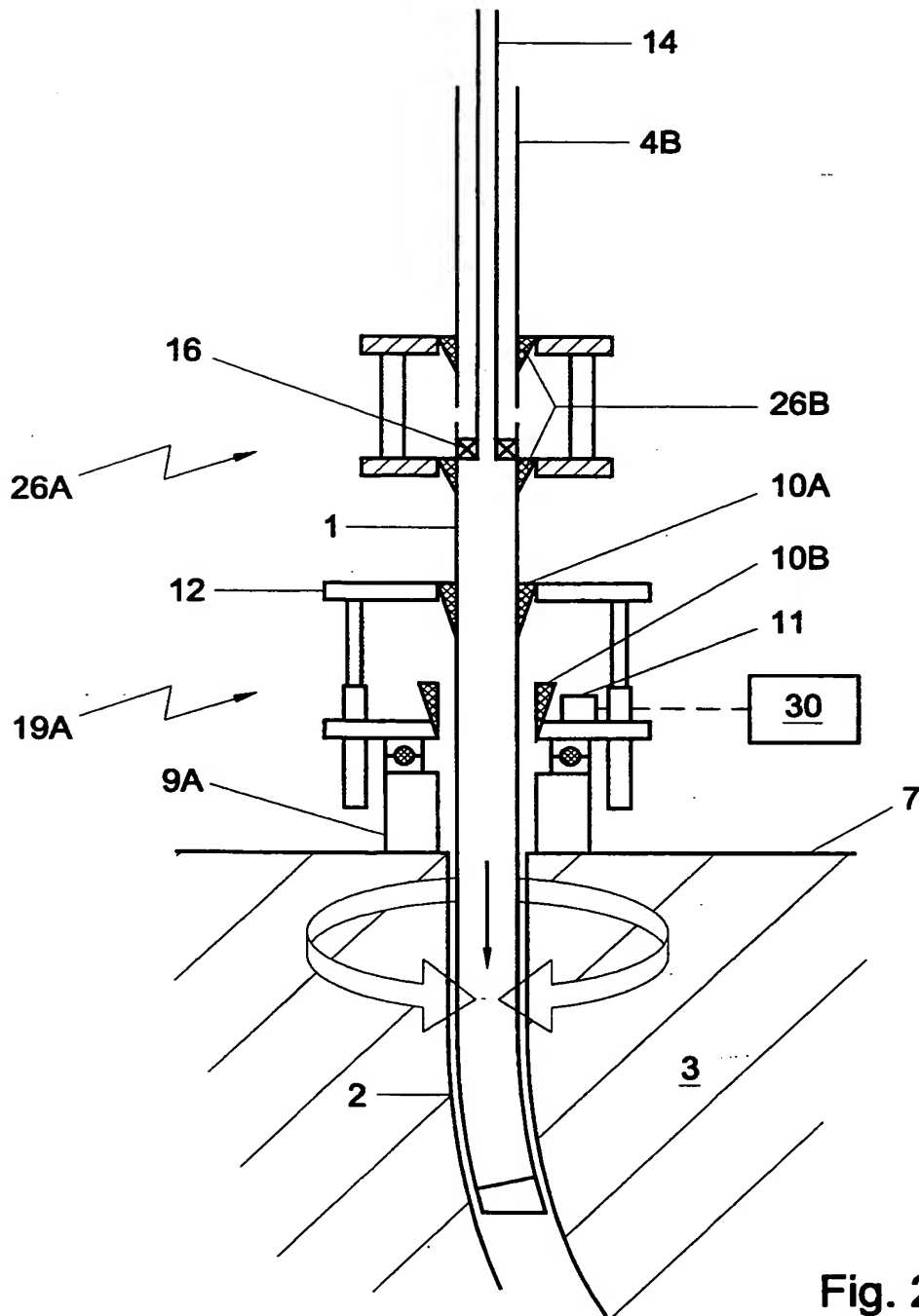


Fig. 2A

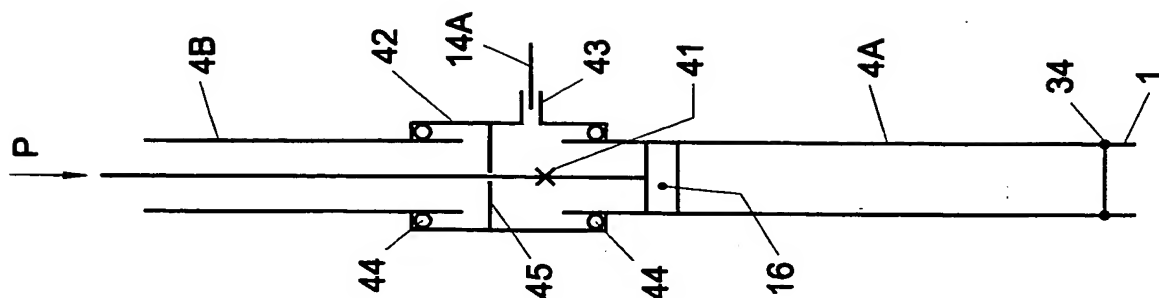


Fig. 3E

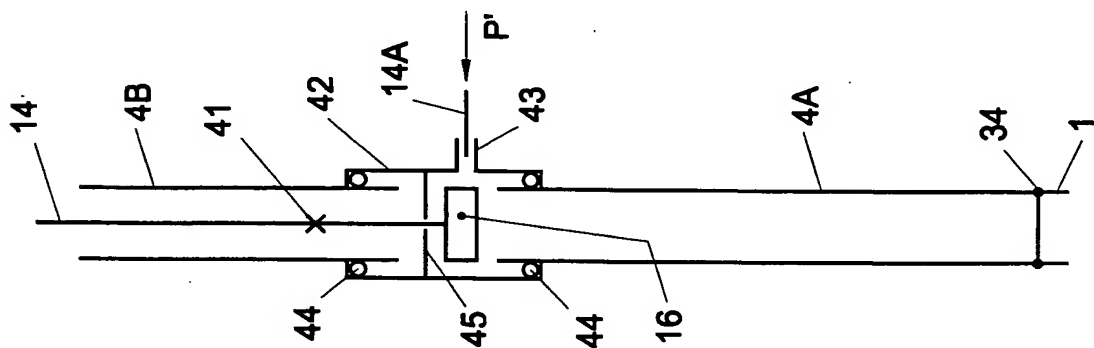


Fig. 3D

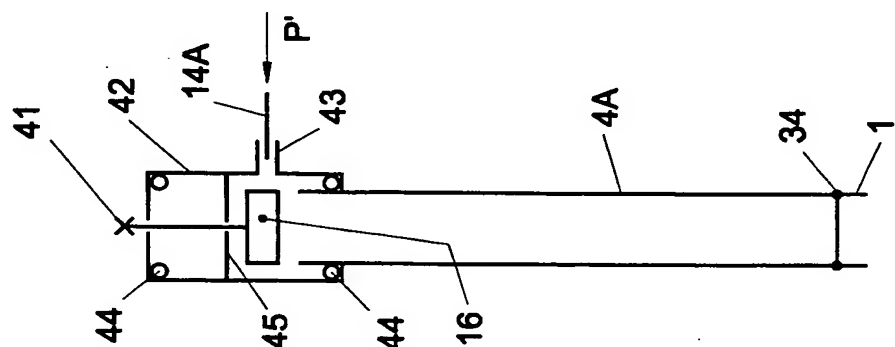


Fig. 3C

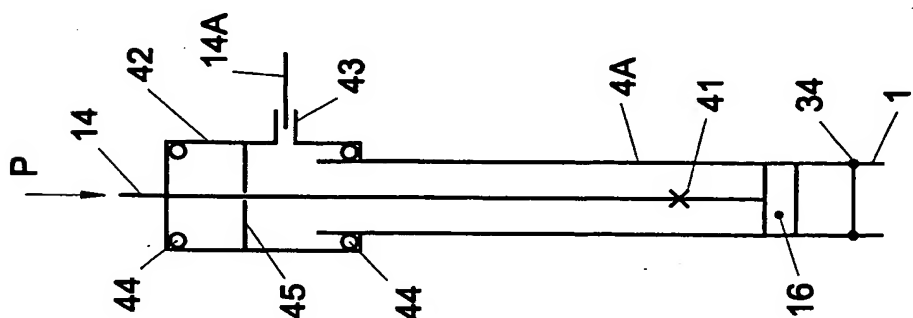


Fig. 3B

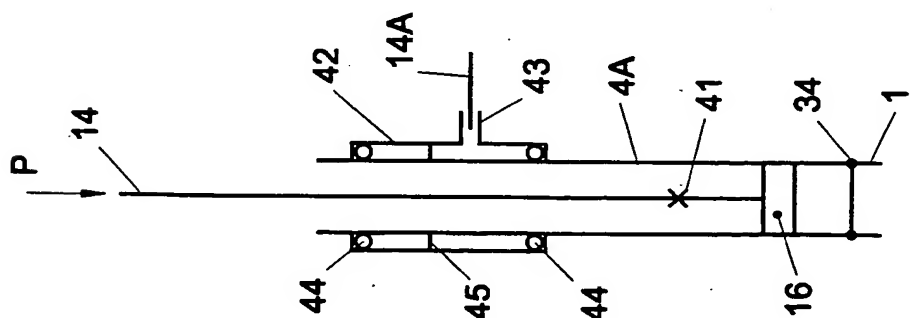


Fig. 3A

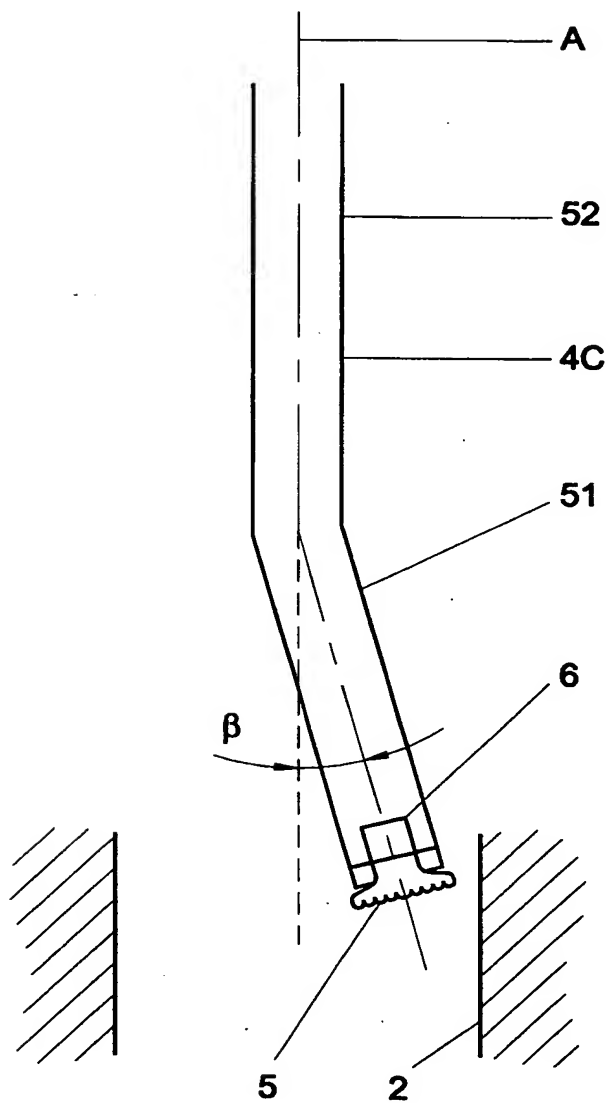


Fig. 4

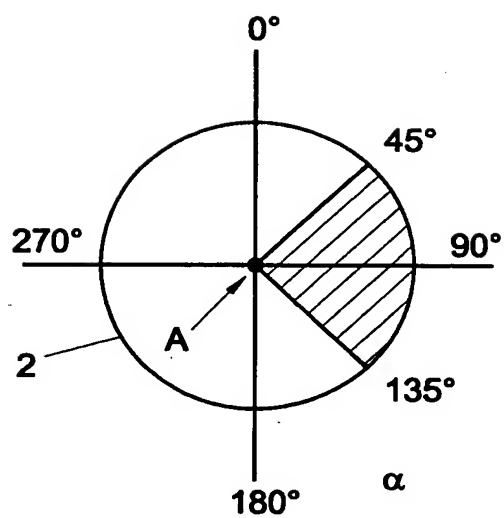


Fig. 5

## INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/NL 99/00586

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 E21B3/025 E21B7/24 E21B21/01 E21B7/06 E21B4/20  
E21B19/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 591 922 A (ALLARD) claim 1 ---	1,2,19, 20
X	GB 521 018 A (HOLMAN BROTHERS LIMITED) claim 1 page 3, line 50 - line 53 ---	1,2,19, 20
X	FR 2 393 114 A (BAUAKADEMIE DER DEUTSCHEN DEMOKRATISCHEN REPUBLIK) 29 December 1978 (1978-12-29) page 1, line 1 - line 5 page 5, line 1 - line 9 ---	1,2,6,8, 9,19,20
Y	---	10
	-/--	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

## \* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

8 June 2000

Date of mailing of the international search report

03.10.2000

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Authorized officer

SOGNO M.G.



# INTERNATIONAL SEARCH REPORT

International Application No.  
PCT/NL 99/00586

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No. .
X	GB 596 715 A (ALLARD)  page 1, line 93 - line 102 page 2, line 81 - line 86 page 2, line 63 - line 76 page 1, line 83 - line 89	1,2,5-8, 19-21
Y	---	10
X	DE 18 14 728 A (SALZGITTER MASCHINEN AG) 9 July 1970 (1970-07-09) page X	1,2,9, 19,20
X	---	
X	DE 11 71 848 B (BADE & CO. G.M.B.H.)  the whole document	1,2,9, 10,19,20
A	---	
	US 3 815 691 A (RICHTER) 11 June 1974 (1974-06-11) abstract  -----	4

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/NL 99/00586

## Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

## Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1 - 10, 19 - 21

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

International Application No. PCT/NL 99/00586

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

1. Claims: 1-10,19-21

method for moving a tube in a borehole, comprising a series of alternating rotating movements matching the natural frequency of the tube.

2. Claims: 11-17

method for moving a tube in a borehole, wherein a tip of the tube is advanced along a curved path.

3. Claims: 18,25

method for moving a tube in a borehole and packer with connecting means to a fluid or energy supply.

4. Claims: 22-24

device for moving a tube in a borehole comprising a rotating welding apparatus, further means for surface treatment of the tube.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

NL 99/00586

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 591922	A	NONE	
GB 521018	A	NONE	
FR 2393114	A	29-12-1978	
		DD 142490 A	02-07-1980
		CS 251601 B	16-07-1987
		DE 2817875 A	14-12-1978
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GB 596715	A	NONE	
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US 3815691	A	11-06-1974	